SILVA BALCANICA

Silva Balcanica 26(2): 43–54 (2025)
doi: 10.3897/silvabalcanica.26.e152285

RESEARCH ARTICLE

Effect of tree shelters on the survival and growth of deciduous tree species 6 years after afforestation

Krasimira Petkova[1], Nasko Iliev[1], Martin Borisov[2], Martin Sattler[3]

[1]*University of Forestry, 10 "St. Kliment Ohridski" blvd., 1797 Sofia, Bulgaria*
[2]*Hans-Watzlik Str.18, 89312 Günzburg, Germany*
[3]*Fiberweb Geosynthetics Ltd, 12 – 14 Aberaman Park, Aberdare CF44 6DA, United Kingdom*

Corresponding author: Krasimira Petkova (kpet@abv.bg)

Academic editor: Veselka Gyuleva | Received 7 March 2025 | Accepted 24 May 2025 | Published 23 July 2025

Citation: Petkova K., Iliev N., Borisov M., Sattler M. 2025. Effect of tree shelters on the survival and growth of deciduous tree species 6 years after afforestation. Silva Balcanica 26(2): 43–54. https://doi.org/10.3897/silvabalcanica.26.e152285

Abstract

The effect of tree shelters on the survival and growth in height and diameter of three tree species: common beech (*Fagus sylvatica* L.), sycamore (*Acer pseudoplatanus* L.) and sessile oak (*Quercus petraea* Matt. (Liebl.)), was studied. The study was conducted in two experimental plantations established in the spring of 2018 at the Training and Experimental Forest Range Petrohan ((North-Western Bulgaria). Four experimental variants with tree shelters – Tubex Ventex Classic, Tubex Ventex Clear, Layflat Shelterguard, Layflat Treeguard and a control one (without tree shelters) were used. Twenty to twenty-seven seedlings in three replications of each variant and tree species were planted. The experimental plantation 1 was established on an east-facing flat terrain at an altitude of 600 m. The soil is Grey Luvisol mixture of sandy and clay, slightly stony, and very deep. The site class is medium rich to rich. The experimental plantation 2 is located in a high-density game area. The area is a meadow, facing north, with an 8° slope and altitude of 850 m. The soil is Dystric-Eutric Cambisol, a mixture of sandy and clay, slightly stony and deep. The site class is medium rich to rich. In the autumn of the 6-th year after the establishment of the plantations, survival was assessed and the height and root collar diameter of all seedlings from each variant and replication were measured. Survival is relatively high in the tree shelter variants, while it is significantly lower in the control variant. Height growth is better in the tree shelter variants, especially in the variants with ventilated tree shelters A and B, in which the highest percentage of seedlings with a height greater than that of the tree shelters was also found. The tree shelter variants have a larger root collar diameter, but in some cases the difference with the control (without tree shelters) is not statistically significant. For future afforestation, the ventilated tree shelters Tubex Ventex Classic and Tubex Ventex Clear could be recommended.

Copyright *Krasimira Petkova*. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Keywords
Acer pseudoplatanus, Fagus sylvatica, root collar diameter, height, *Quercus petraea*.

Introduction

The use of tree shelters is important for better survival and initial growth of woody plants. It began in the 1970s in Great Britain (Tuley, 1985) and subsequently gained popularity in a number of countries. A number of publications highlight the effect of tree shelters with different lengths on the survival and growth of a number of deciduous tree species. Vaughan et al., (2018) studied the survival and height growth of seedlings of various native oaks in the second year after planting in Alabama with and without tree shelters. Tree shelters of different lengths were used – 0.76, 0.91 and 1.52 m. The use of a longer shelter was found to promote survival and growth. Mayhead, Boothman (1997) studied the effect of tree shelter height on the growth of young sessile oak (*Quercus petraea*). Four experimental treatments were imposed: control with no tree shelter and tree shelters of heights 0.6, 1.2 and 1.8 m. Treatments had no significant effect on tree survival. Taller shelters stimulated growth in height, but not in diameter. The experiment highlights serious problems with the stability of the seedlings when using the highest tree shelters – 1.8 m. With tree shelters with a height of 1.2 m, a good balance of height and diameter is maintained and good acclimatization of the seedlings after removing the shelters. A protector height of 0.6 m promotes growth in height to a large extent and is a prerequisite for a good balance in terms of diameter, biomass production and root to stem ratio.

Some publications discuss the influence of different types of tree shelters. Thyroff et al. (2022) studied the influence of two types of tree shelters (solid wall and mesh) and control to protect against herbivore damage and provide a better microclimate for the growth of *Quercus virginiana* seedlings in the southern United States. After two growing seasons, it was found that the survival of protected seedlings, both with solid wall and mesh tree shelters, was higher than that of unprotected ones, but those with solid walls were more effective in terms of animal damage. These shelters have positively altered the seedling microclimate, resulting in the greatest growth response. The study by Mechergui, Pardos (2017) examined the effect of vented and non-vented shelters on the survival and height growth of cork oak trees in the fourth year after the establishment of the experiment. Tree shelters did not have a significant effect on seedling survival rate during the study period, whereas both vented and non-vented shelters significantly increased the seedling mean height during the four years. The root collar diameter of seedlings protected with tree shelters was smaller than unprotected ones. Better height growth but weaker diameter growth of cork oak seedlings protected with tree shelters in Morocco was also reported in a 9-year study by El Alami et al. (2023).

In Spain, at two sites – with contrasting precipitation and temperature regimes – two tree species *Quercus ilex* and *Pinus halepensis* were tested with the following protection options – tubes with light transmittance of 20, 40, 60 and 80% and a control protection with mesh tree shelters. Survival, height growth and biomass accumulation were studied. The results support the use of tree shelters with higher light transmission, but caution should be exercised when using them for species with slower root growth under limited water availability. No enhanced growth was observed when plants were experiencing water stress (Oliet et al., 2021).

In Bulgaria, the use of tree shelters for seedlings from the company Tubex (www.tubexdeutschland.de) began in the spring of 2016 in the Training and Experimental Forest Range Yundola with coniferous tree species (Petkova et al., 2022a). In 2018, similar experiments, but with deciduous species, were launched in the Training and Experimental Forest Range Petrohan. Initial results from studies in the second and third years after the establishment of the experimental plantations of common beech, sycamore and sessile oak have been published (Petkova et al., 2022b).

The aim of this research was to study the effect of tree shelters on the survival, height and diameter growth of common beech, sycamore and sessile oak in the 6th year after the establishment of the experimental plantations.

Material and Methods

The object of this research were two experimental plantations (EP1 and EP2), established in the spring of 2018 in the Training and Experimental Forest Range in Petrohan (North-Western Bulgaria). EP1 was established on an east-facing flat terrain at an altitude of 600 m (43.187247° N, 23.141207° E). The soil is Grey Luvisol mixture of sandy and clay, slightly stony and very deep. The site class is medium rich to rich. The plantation was established after windthrow in a Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) plantation. The stumps were pushed with a bulldozer and the area was cleaned and levelled. EP2 was located in a high-density game area. It is a meadow, facing north, with an 8° slope and an altitude of 850 m (43.177994° N, 23.133380° E). The soil is Dystric-Eutric Cambisol, a mixture of sandy and clay, slightly stony and deep. The site class is medium rich to rich. The climate in the region is temperate with an average annual temperature of 10.2 °C and annual precipitation of 1004 mm. The duration of the growing season is about 6 to 6.5 months (Kyuchukova et al. 1983; Koleva, Peneva 1990).

The soil in EP1 is Gray Luvisol, poor in humus, well stocked with nitrogen, poorly stocked with phosphorus and potassium and slightly acidic pH. EP2 is located on brown forest soil (Dystric-Eutric Cambisol), poor in humus, moderately stored in nitrogen, poor in phosphorus, moderately stored in potassium and acidic pH (Petkova et al., 2022b).

Method

Four experimental variants with tree shelters – Tubex Ventex Classic (A), Tubex Ventex Clear (B), Layflat Shelterguard (C), Layflat Treeguard (D) and a control one (without tree shelters) were used. Detailed information about the individual types of tree shelters has been published (Petkova et al., 2022b). Twenty to twenty-seven seedlings in three replications of each variant and tree species were planted. All tree shelters are 120 cm high.

The afforestation in EP1 was carried out on 17.04.2018 under the 2.0×1 m scheme, and the tree shelters were installed on 27 and 30.04.2018. In EP2 the afforestation was performed on 19.04.2018 and the installation of the tree shelters – on 03.05.2018. The planting of the seedlings in both experimental plantations was done with a motor drill. Common beech seedlings were 1-year-old, and those of sycamore and sessile oak – 2-year-old. In the autumn of the sixth year after the establishment (2023), the height and root collar diameter of the seedlings were measured.

Statistical analysis

The statistical processing of the data was done using the SPSS software at a confidence interval of 95%. The homogeneity of the variance by groups for the individual factors studied was checked using the Levene test. If the homogeneity of the variance was proven, the influence of the factors studied was sought using a one-way analysis of variance ANOVA. To prove differences in the mean values, a Post Hoc test was used. Statistically identical values are marked with the same letter, and different ones – with a different letter.

Results and discussion

Survival

In experimental plantation 1 (EP1), the highest average survival rate was the sessile oak with 84.4%. In second place with 76.2% was the sycamore, and in third place was the common beech with 73.3%. In the case of common beech, the highest survival rate was reported in variant B Tubex Ventex Clear, but the differences with the other tree shelter variants were not statistically significant (Table 1). The lowest survival rate was in the control variant (45.8%) and the difference with the other variants was of high statistical significance (Table 2). In the case of the sycamore, differences were found only between variant A, which had the highest survival rate (89.03%), and the control, but they were not statistically significant (Table 2).

In experimental plantation 2 (EP2) which is in a high-density game area, survival was best for the sessile oak, with an average survival rate of 72.7%. In second and third place were the sycamore and the common beech, respectively, but the

average survival rate for the two species was close – 61.1 and 60.7%, respectively (Table 1). In the case of common beech, the highest survival rate – 79.4% was recorded in variant B, and the lowest – 43.9% in the control, but the differences were not statistically significant (Table 2).

In the sycamore, the survival rates in the tree shelter variants were relatively close (from 65 to 79.2%) and the differences were not statistically significant. The difference between the control and the tree shelter variants was statistically significant (Table 2). In the control, the survival rate is only 6.7%. The large percentage of losses in the control is mainly due to damage by game to unprotected saplings (most seedlings had damaged top shoots). In the sycamore, the difference was statistically significant (Table 1) between variant A with the best survival (91.7%), variant C (65%) and the control (40%). In the other tree shelter variants, there were differences in survival, but they were not statistically significant.

Table 1. Survival by site, species and treatment.

Object number	Treatment	Common beech	Sycamore	Sessile oak
EP 1	A Tubex Ventex Classic	80.57±6.07b	89.03±3.83c	95.07±1.23b
	B Tubex Ventex Clear	86.10±1.40b	82.73±2.47bc	97.53±1.23b
	C Shelterguard	72.23±3.68b	78.57±11.58bc	87.67±4.45ab
	D Tree guard	81.93±7.35b	78.23±8.03bc	83.93±6.49ab
	E Control	45.78±4.17a	52.33±20.62ab	66.80±13.49a
	Average survival	73.3	76.2	84.4
EP 2	A Tubex Ventex Classic	60.00±10.00	79.27±2.98b	91.67±8.33c
	B Tubex Ventex Clear	79.43±5.31	78.33±8.82b	80.00±5.77bc
	C Shelterguard	59.43±7.08	65.00±5.77b	65.00±2.89b
	D Tree guard	60.57±19.01	76.10±12.19b	86.67±4.41bc
	E Control	43.90±17.28	6.67±6.67a	40.00±0.00a
	Average survival	60.7	61.1	72.7

Note: Values marked with the same letters do not differ significantly from each other

Table 2. Significance of results

Object number	Tree species	F	Significance
EP 1	Common beech	10.561	0.0001
	Sycamore	1.526	0.267
	Sessile oak	2.983	0.073
EP 2	Common beech	0.947	0.476
	Sycamore	15.290	0.0001
	Sessile oak	16.628	0.0001

Regarding survival, several publications highlight the positive role of tree shelters (Duerden et al, 2017; Vaughan et al.; 2018, Liović et al, 2019; Thyroff et al., 2022). Dorji et al. (2020) emphasize that the survival of *Quercus semecarpifolia* seedlings is even 3 times better when using tree shelters. Mayhead, Boothman, (1997) and Ponder (2003) point out, however, that the differences in the survival of unprotected and protected seedlings are not statistically significant.

Height growth

In EP 1, the highest average height in the sixth year after afforestation in all variants was characterized by the sessile oak (Fig. 1), with the control variant significantly different from the tree shelter variants (at $p<0.05$). The sessile oak of variant B Tubex Ventex Clear was most affected by the tree shelters, in which the average height was almost 160 cm. When studying the second and third years after afforestation in the same EP also showed that the sessile oak from variant B was the tallest (Petkova et al., 2022b). In the case of sycamore, the control was significantly ($p<0.05$) different from variants A, B and D (Fig. 1). Its slow growth is striking. The average height in the tree shelter variants was only 28 – 36 cm, and in the control variant the average height was 20 cm. Similar values were characteristic of the sycamore from the same EP and in previous studies (Petkova et al., 2022b), i.e. for 3 years its height growth was minimal. In the case of common beech, the seedlings of variant B were the tallest – approximately 120 cm, and the difference with variants A, C and E was significant. The average height of the beech from variant C and the control (variant

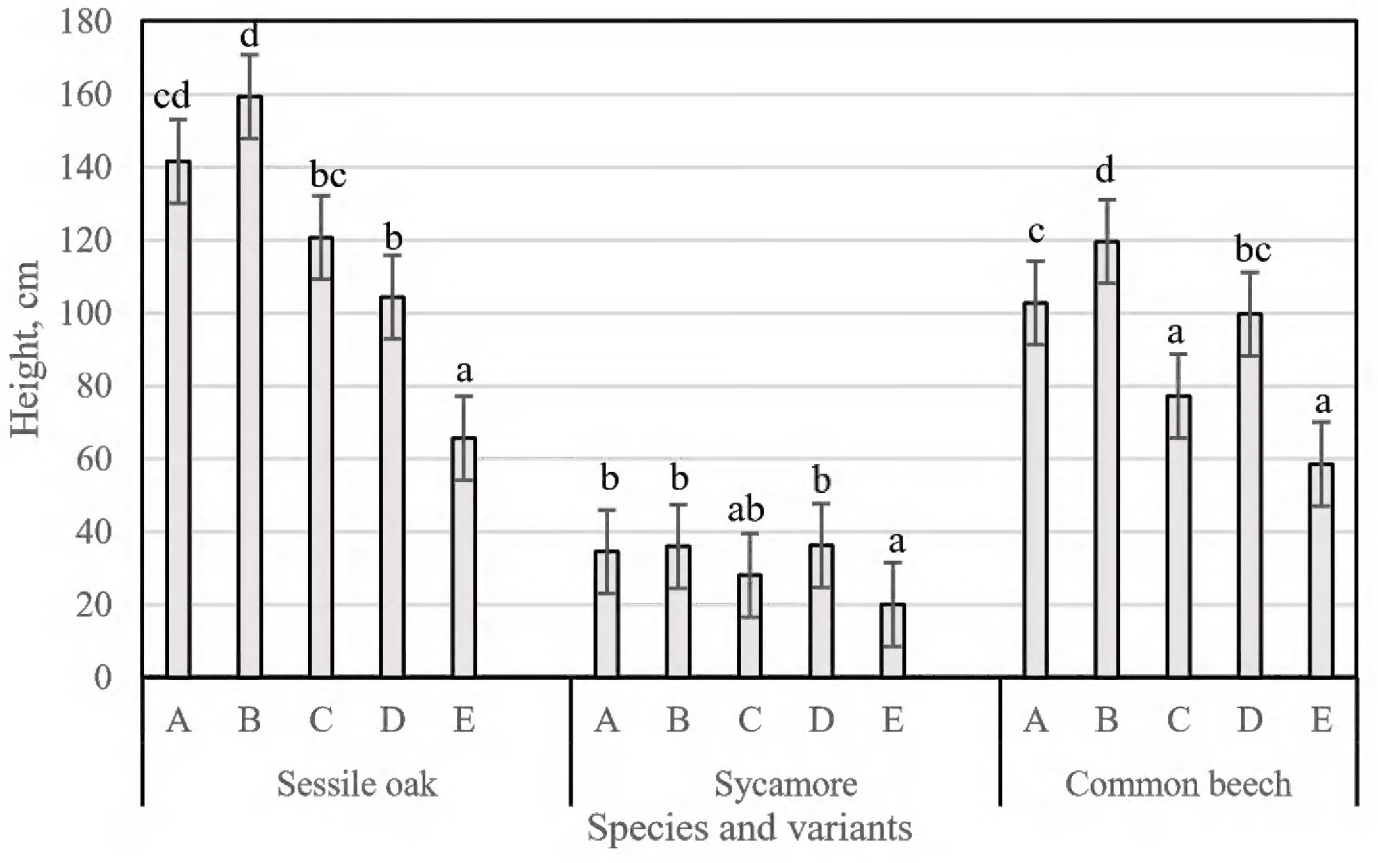

Fig. 1. Height growth at EP 1

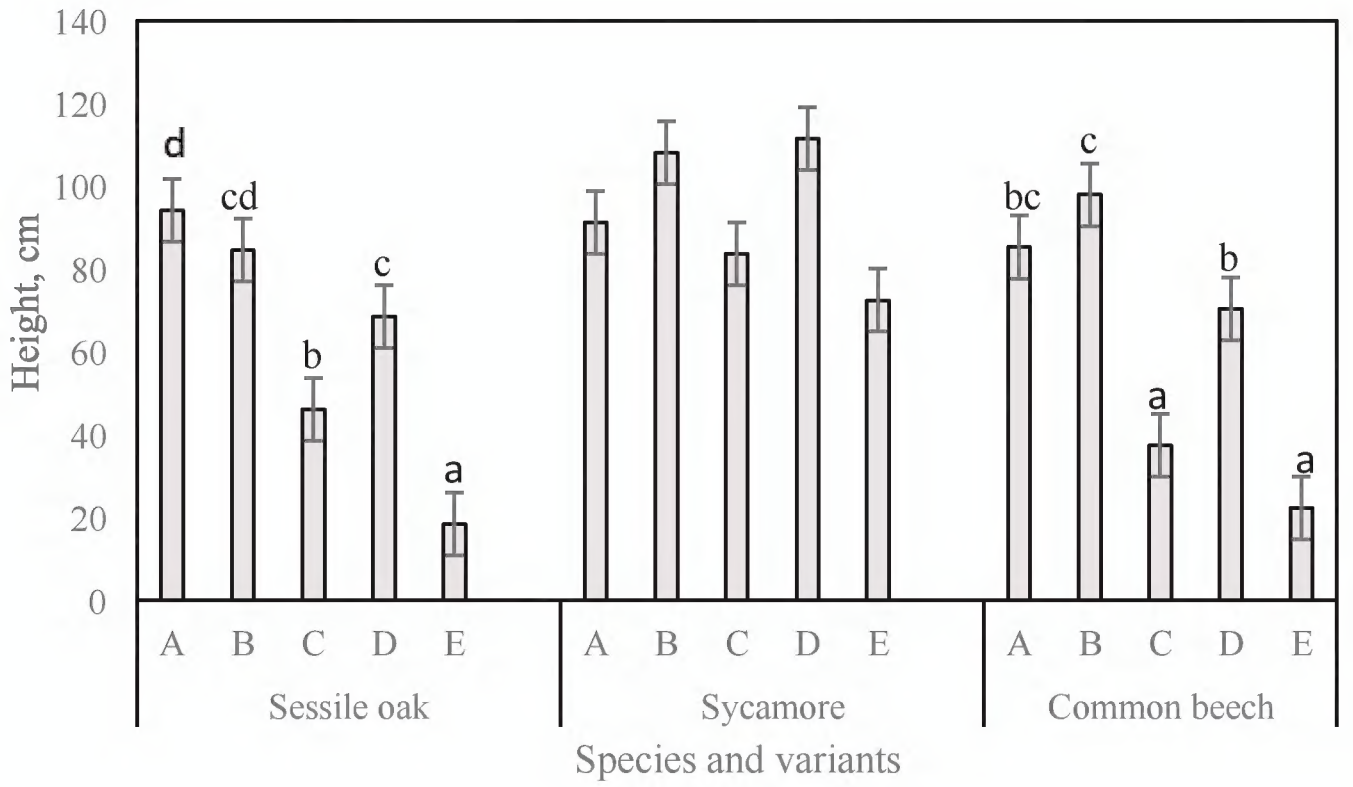

Fig. 2. Height growth at EP

E) differed significantly from the others (at $p<0.05$), but without a significant difference between them.

Unlike experimental plantation 1 (EP1), in experimental plantation 2 (EP2) the arrangement of the species is different (Fig. 2). The highest average height was characterized by the sycamore from variant D (111.5 cm), followed by variant B (108.1 cm). The lowest average height of the species was in the control variant E (72.5 cm), but the differences are not statistically significant. The average height values for the sycamore in a previous study in the same experimental plantation were not statistically significant either (Petkova et al., 2022b). In the case of the sessile oak, the average height is the largest in variant A (94.1 cm), but the difference in the average height of variant A with variants C, D and E is significant (at $p<0.05$). In the case of common beech, the differences in the average height between the individual variants are statistically significant (at $p<0.05$), and in particular, variant B differs significantly from variants C, D and E (Fig. 2). Variants C and E do not differ significantly from each other. Variant A is the only one that does not differ significantly from the others. In all three tree species, the weakest growth in height was observed in the control variant E due to the significant percentage of damage by game.

A positive effect of tree shelters on height growth was found by Ponder (2003), Mechergui, Pardos (2017) and El Alami et al. (2023). Vaughan et al. (2018) found a different impact on the height growth of oak seedlings on tree shelters of different heights. 0.76 m, 0.91 m and 1.52 m, and in the second year after afforestation the average height of the seedlings was 0.85 m, 0.96 m and 1.75 m, i.e. the highest tree shelters were the most effective. Liović et al. (2019) seedlings of *Quercus robur*

which were three times taller when protected with polypropylene tree shelters, compared to unprotected ones. Dorji et al. (2020) reported a twofold greater height of seedlings of *Quercus semecarpifolia* protected with tree shelters compared to unprotected ones.

In the sixth year after the establishment of the plantations, some of the seedlings of all three tree species were taller than the tree shelters. The highest percentage of tall seedlings was found in the sessile oaк in both experimental plantations in all protection variants (Table 3). The ventilated tree shelters Tubex Ventex Classic (variant A) and Tubex Ventex Clear (variant B) particularly stimulated growth in height. In these variants, over 60% of tall seedlings were found in the sessile oak of EP 1 (maximum height 320 cm in variant B). Also, in the sixth year after afforestation for *Quercus robur,* Liović et al. (2019) found an average height of 200 cm, and a maximum of even 400 cm. In the case of common beech from the same plantation (EP1), the overgrown tree shelter seedlings from variants A and B were 32.8 and 42%, respectively (Table 3). It should be noted that in the case of sessile oak, in the third year, in all protection variants, some seedlings outgrow the tree shelters, as well as in the case of common beech, but only in variant B (Petkova et al., 2022b). Ponder (2003) notes that red oak, black walnut and Pennsylvania ash trees began to emerge from the 120-cm-tall shelters after the second growing season, but not in large numbers until the fourth growing season. As highlighted above, the sycamore from EP2 grows extremely slowly and at this stage only single seedlings, mainly from variants A and B, are taller than the tree shelters. In EP2, a higher percentage of tall seedlings was also reported in these 2 variants and in all three species. In the case of sycamore, a relatively high percentage of seedlings that outgrew the tree shelters was found even in variant D (mesh tree shelters) – Table 3. In common beech, variant C had the lowest percentage of tall seedlings, while in EP2 there were none. The impact of this type of tree shelter was the weakest, probably due to the lack of ventilation (these tree shelters are made of mesh with foil).

Table 3. Proportion of seedlings taller than the tree shelters

Object number	Variant	Sessile oak		Sycamore		Common beech	
		Nmb.	%	Nmb.	%	Nmb.	%
EP1	A	50	64.9	3	4.4	19	32.8
	B	50	63.3	2	3.0	26	42.0
	C	28	39.4			8	15.4
	D	20	29.8	1	1.7	19	32,2
EP2	A	22	40.0	11	23.9	9	28.1
	B	15	31.2	19	40.4	16	36.4
	C	5	12.8	10	25.6		
	D	8	15.4	18	41.9	5	15.1

Root collar diameter growth (RCD)

The best result at root collar diameter growth EP1 (Fig. 3), as well as in height growth, was found in the sessile oak in variant B (18.2 mm), which differed significantly (at $p<0.05$) from the other variants (Fig. 3). For the same species, significant differences in this indicator are also found between variants C and E. In common beech, variant B (12.7 mm) was also characterized by the largest root collar diameter, which differs significantly (at $p<0.05$) from variant A and the other variants. The same indicator did not differ significantly in variants C, D and E (Fig. 3). In the sycamore, the root collar diameter growth was the weakest, with the differences in the tree shelter variants being insignificant, the only significant difference at $p< 0.05$ being noted between variant D and the control (variant E) – Fig. 3.

Unlike EP1, in EP2, the largest root collar diameter in all variants was recorded for the sycamore (Fig. 4) from variant D (12.4 mm). The average root collar diameter of variant D differs significantly (at $p<0.05$) from variant A and E, but not from variants B and C. In second place in terms of RCD of the seedlings was the common beech, in which the largest value of the average root collar diameter was also established in variant D (11 mm), but it did not differ significantly from that in variant B. It is also striking that the RCD of the control variant did not differ significantly from that of variants A and C (Fig. 4). In the case of the sessile oak, variant A stands out with the largest average root collar diameter of the seedlings and differs significantly (at $p<0.05$) from variant C and from the control E. In all three species, the control (variant E) was characterized by the weakest growth both in height and in RCD.

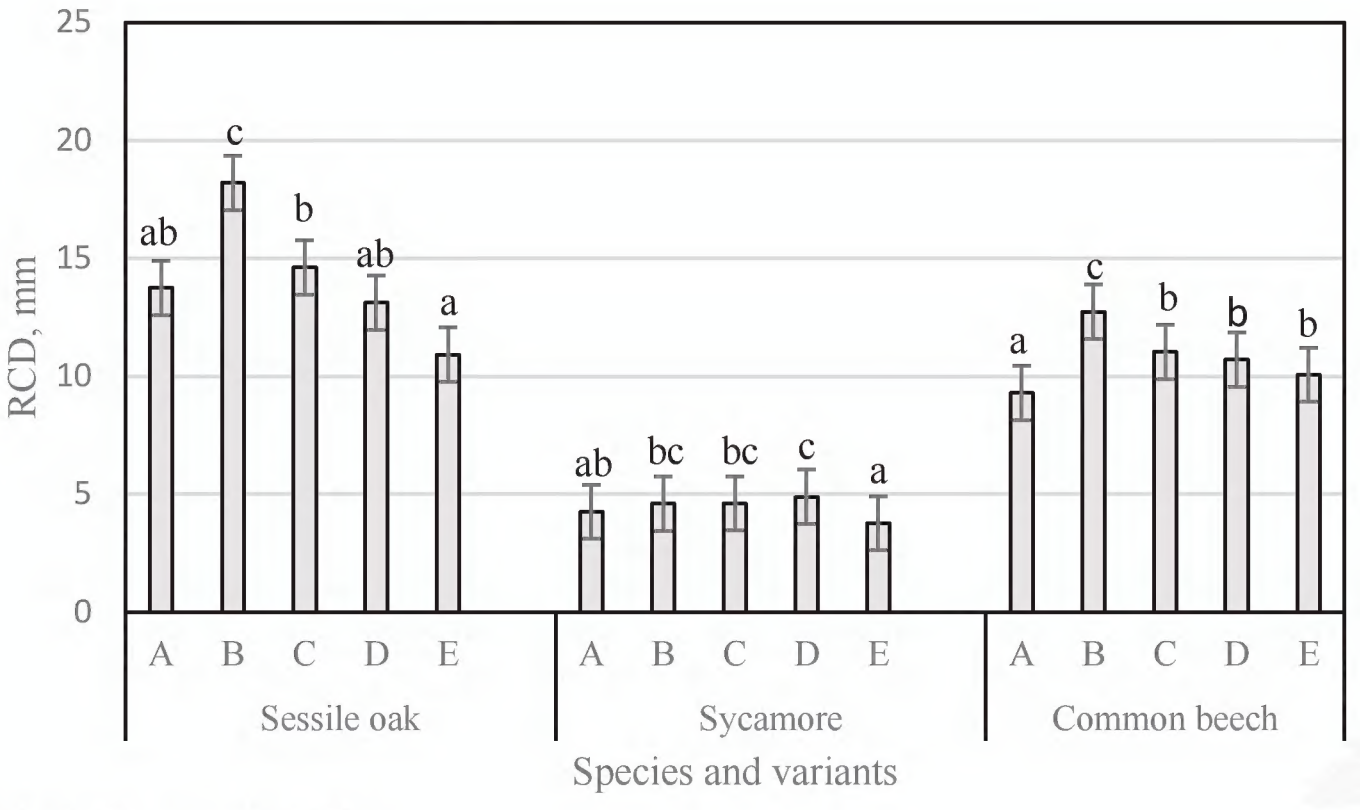

Fig. 3. RCD growth at EP1

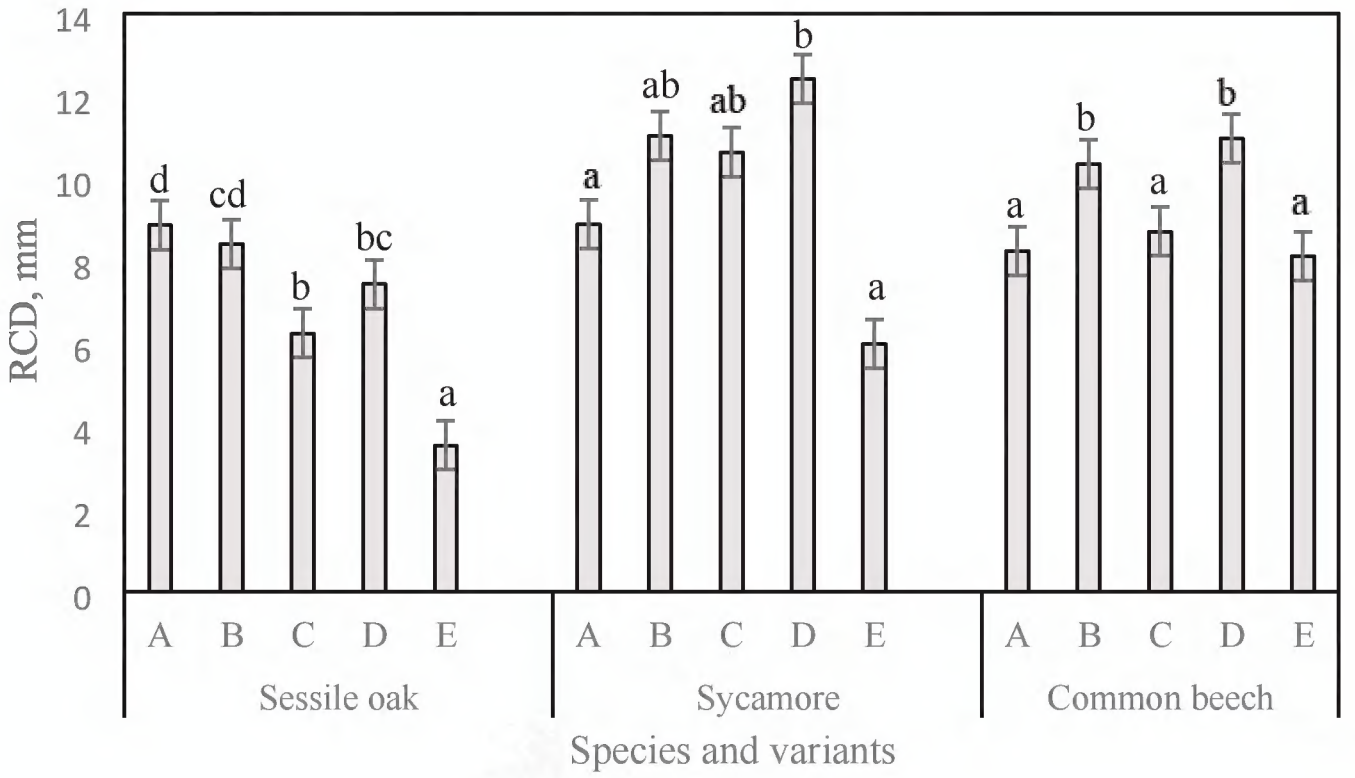

Fig. 4. RCD growth at EP2

In both experimental plantations, the root collar diameter was smaller in unprotected seedlings than in protected ones, but in some cases the differences were not statistically significant. However, some authors found that the root collar diameter in the control variants was larger compared to the variants with tree shelters (Mayhead, Boothman, 1997; Mechergui, Pardos, 2017; El Alami et al., 2023). In our experiments, the seedlings in the control variants were significantly smaller in height than the variants with tree shelters. For example, in sessile oak from EP2, the average height in variant A was almost 5 times greater than that in the control (Fig. 1). This difference probably also reflects on the root collar diameter growth. In this experimental plantation, the seedlings of all three species in the variants without tree shelters were damaged annually by game, which can explain the minimum size even in the sixth year. In experimental plantation 1 (EP1), seedlings in the control variants experience serious competition from weeds and self-settled woody vegetation (mainly birch) and are also significantly lower than the variants with tree shelters.

Conclusion

The survival of common beech, sycamore and sessile oak is relatively good in the tree shelter variants. The highest survival rate in both experimental plantations is reported for sessile oak, followed by sycamore and common beech, with slightly better survival rate in experimental plantation 1. The survival in the control variant is significantly lower for all three species, and no surviving seedlings were reported in some replications.

- The tree shelters in all their variants stimulate height growth to a greater extent. Growth is especially activated in variants A and B, where the highest percentage of seedlings outgrowing the tree shelters is observed.
- Root collar diameter growth is less affected, more often better in the tree shelter variants, but in some cases the differences between the control variant and tree shelter variants are not statistically significant.
- A significant difference in the growth of the sycamore was noted in the two experimental plantations. It was significantly more active in EP 2, where in variants A and B a large percentage of seedlings which outgrew the tree shelters was established. It is likely that the growing conditions in EP2 are more favorable for the growth of the sycamore.
- For future afforestation with the studied species, the ventilated tree shelters Tubex Ventex Classic and Tubex Ventex Clear could be recommended.

References

Dorji T., Facelli J.M., Norbu T., Delean S., Brookeses J.D. 2020. Tree shelters facilitate brown oak seedling survival and establishment in a grazing-dominant forest of Bhutan, Eastern Himalaya. Restoration Ecology 28 (5), 1145–1157. https://doi.org/10.1111/rec.13176

Duerden C.E., Jenkins T., Evans H., Gwynn-Jones D. 2017. Survival, height and tree stability responses of *Quercus petraea*, two decades after the introduction of different tree shelter types. Quarterly Journal of Forestry 111 (1), 26–31.

El Alami S.L., El Aboudi A., El Antry S., El Mnouar E.A, Dallahi Y., Rabhi A. 2023. Effect of Tree Shelters and Regeneration Method on Survival and Growth of Cork Oak Plantations in the Maamora Forest, Morocco. Journal of Ecological Engineering 24 (7), 360–374. https://doi.org/10.12911/22998993/165784

Koleva E., Peneva R. 1990. Climate guide. Precipitations in Bulgaria. BAS, Institute of Meteorology and Hydrology, Sofia. 169 pp. (In Bulgarian).

Kyuchukova M., Moraliyski E., Koleva E., Stoychev St., Blaskova D., Ivanov P., Lingova St. 1983. Climate guide for V.R. Bulgaria. Vollume 3: Air temperature, soil temperature, frost. Main Department of Hydrology and Meteorology at the Bulgarian Academy of Sciences, Institute of Meteorology and Hydrology, Sofia, 440 pp. (In Bulgarian).

Liović B., Tomašić Ž., Dubravac T., Licht R., Turk M. 2019. The Effect of Polypropylene Tree Shelters on Growth and Survival of Pedunculate Oak Seedlings (*Quercus robur* L.). South-East European forestry 10 (1), 89–96. DOI: https://doi.org/10.15177/seefor.1907

Mariotti B., Maltoni A., Jacobs D.F., Tani A. 2015. Tree shelters affect shoot and root system growth and structure in *Quercus robur* during regeneration establishment. European Journal of Forest Research 134, 641–652. DOI 10.1007/s10342-015-0878-y

Mayhead G.J., Boothman I.R. 1997. The effect of tree shelter height on the early growth of sessile oak (*Quercus petraea* (Matt.) Liebl.). Forestry 70 (2), 151–155.

Mechergui T., Pardos M. 2017. Impacts of mulching and tree shelters on cork oak (*Quercus suber* L.) seedling survival and growth after four growing seasons. In: Revue d' Écologie (La Terre et La Vie) 72 (4), 410–424. https://doi.org/10.3406/revec.2017.1901;

Oliet J.A., Puértolas J., Valenzuela P., Vázquez de Castro A. 2021. Light Transmissivity of Tree Shelters Interacts with Site Environment and Species Ecophysiology to Determine Outplanting Performance in Mediterranean Climates. Land 10, 753. https://doi.org/10.3390/ land10070753

Petkova K., Iliev N., Borisov M., Sattler M. 2022a. Effect of tree shelters on the survival and growth of coniferous tree species in Central South Bulgaria. Silva Balcanica 23 (1) 67–78, doi: 10.3897/silvabalcanica.22.e84286

Petkova K., Iliev N., Borisov M., Sattler M. 2022b. Effect of tree shelters on the survival and growth of deciduous tree species in North-Western Bulgaria. Forestry ideas 28, 1 (63), 151–162.

Ponder F.Jr. 2003. Ten-Year Results of Tree Shelters on Survival and Growth of Planted Hardwoods. Northem Journal of Applied Forestry 20 (3), 104–108.

Thyroff E.C., Burney O.T., Oliet J.A., Redick C.H., Jacobs D.F. 2022. Toward Identifying Alternatives to Fencing for Forest Restoration: Tube Shelters Outperform Mesh Shelters for Deer Browse Protection of Live Oak, *Quercus virginiana*. Land 11, 966. https://doi.org/10.3390/ land1107096

Tuley G. 1985. The growth of young oak trees in shelters. Forestry 58 (2), 181–195.

Vaughan B., Smith R.C., Ankumah R. 2018. Observational Assessment of the Effects of Tree Shelters on Growth and Survival of Bottomland Saplings. International Journal of Applied Science and Technology 8 (1), 1–10.